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AERODYNAMIC STUDY OF SPAN WISE MORPHING WING

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ABSTRACT

The frame of the wing, type of the wing and camber angles derive its own aerodynamic characteristic properties. However, innovations and development in new technology are pushing the concept of a wing that can vary its camber and shape to widen its operating conditions to give maximum aerodynamic efficiency. This would make it able to adapt itself to different flight conditions. Present research deals with improvement in the operation and aerodynamic performance at various altitude conditions (like takeoff, cruise, landing, etc). These improvements accomplished during viscous drag compromising by encouraging laminar flow over the wing. To reach such aerodynamic abilities, at any rate of flow conditions, the exterior part of the wing is subjected to twist (in-flight morphing) to maintain the drag as/at? lowest achievable value.

This paper discusses designing a span wise morphing wing, which allows a change in the aspect ratio while, at the same time, supporting structural wing loads. The aerofoil of the wing is designed using NACA 0012, increase in wing aspect ratio and span ratio is calculated. Using FLUENT, an ANSYS CFD solver, the performance and its aerodynamic nature of each wing shape of the span, morphing about 20% and 40%, are concluded.

KEYWORDS: NACA 0012, ANSYS & Morphing Wing

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Original Article

INTRODUCTION

Morphing/adaptive wing is the idea, so as to transform its design to entertain several flight conditions. The ultimate bring into play an adaptive approach, which allows the wing to fluctuate its geometric parameters like camber, chord length, thickness, etc., during flight. During various flight conditions, a situation of change in flow parameters, such as wind speed or direction, results in poor aerodynamic performance of wing. Huge hardwork was made to understand the air developed by Leonardo da Vinci just before the end of 1400s. Otto Lilienthal initiated aerodynamic trails belatedly during 1800s.

He performed his studies on gliding of birds. Based on those observations, construction of gliding planes that are similar to present generation hand-gliders were possible. Lilienthal was the first person to recognize the significance of articulately formed wing segment. He originated the camber and suitable thickness of the aerofoil to improve aerodynamic efficiency, as compared to a flat plate[8].

By change in the camber, the morphed aerofoil can attain the required lift that eliminates the necessity of usual control surfaces[9]. During morphing with twisting, wing is optimized to achieve low drag and high lift. The sweeping of a wing helps in changing the wing configurations to outfit various flight conditions[6]. Adaptive

morphing uses smart materials to research on aerodynamic circumstances by optimizing the boundary layer profiles to avoid flow separation of the fluid flow during high angle of attack of the wings[5].

Multimorphing aircraft design concepts are being studied by engineers. A changeable span arrangement has the capability to meet up the desires of military and commercial UAVs. Expanding the geometric parameters of wing-like span, aspect ratio and area compromised drag and consequently range/endurance of the vehicle boosted. Smart materials imposed huge applications for morphing wings and are out listed; also different mechanisms were programmed to attain multi-role capabilities to aerospace vehicles[4].

Problem Definition

Wing morphing innovation creates a blueprint to revise design parameters of wing-like aspect ratio and plan form for optimizing operating envelope of flight. Designs so used are adaptive aspect ratio (ADAR) models. The geometric model of the present research is designed in software Creo, as shown in figure 1. We are using NACA 0012 aerofoil to model the 3D wing with a cord length of 0.8 mt and the full span of 1mt respectively.

It has a sweep angle of 30° from nose to tip. Later on, an additional spanstrip is added for morphing the wingspan for about 20% and 40%. These wing models are further designed by changing angle from 0° to 3° and also to 6°.

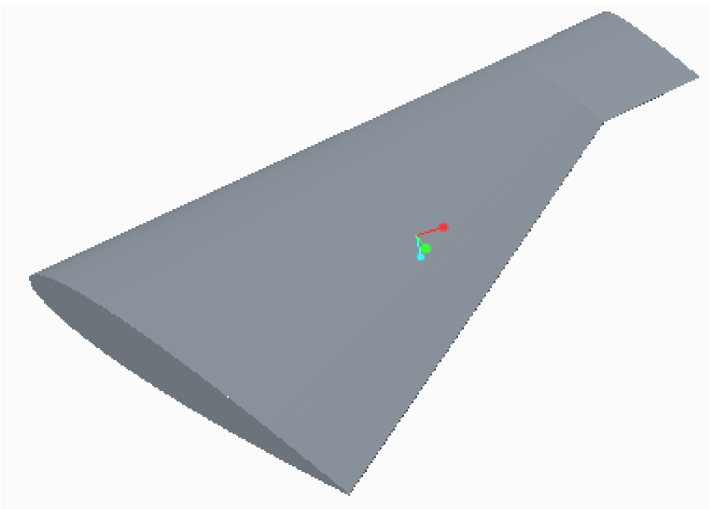


Figure 1: Geometry of Morphing Wing.

MESHING

The main part of CFD analysis is dividing the fluid domain into small volumes known as meshing or grid. Various methods are defined in generating grid cells or elements in the meshing process. These cells are to be solved by all the governing fluid flow equations like continuity, momentum and energy equations. The cell dimension creates a huge difference in the computational time, memory and accuracy of results. By considering all the above factors, the optimized numbers of grid cells are to be defined. Apart from structured or unstructured grid strategies, hybrid grid is more advantageous in all aspects. So, hexagonal or prism elements are used near walls to capture boundary layers' velocity profiles and flow separation. The final mesh model of wing can be seen in figure 2.

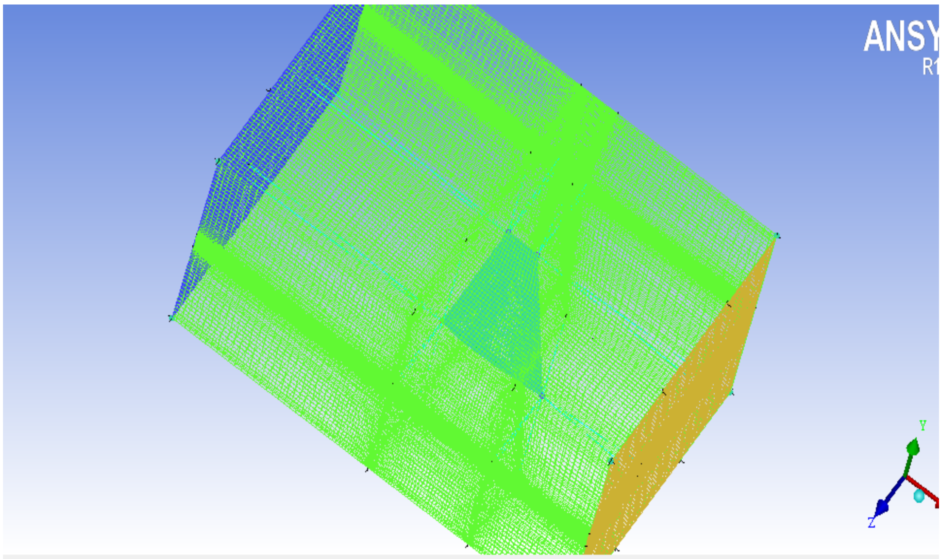


Figure 2: Morphing Wing and Mesh.

COMPUTATIONAL METHODOLOGY

In FLUENT, equations are solved based on Pressure and Spalart-Allmaras (SA) model is opted including viscous effects. Air is the fluid with incompressible flow properties defined. SA one-equation model is the generally used model because of its advantage in developing equilibrium flows, where the turbulent time scales are a great deal and minor than the mean flow time scales.

SA turbulence model and the Menter k-ω shear-stress transport turbulence model are the most commonly used and trustworthy models for Reynolds-averaged Navier-Stokes computations of fluid flows.

RESULTS AND DISCUSSIONS

Initial investigation is performed to study the drag on the wing with and without morphing along with change in AOA of 0^0, 3^0 and 6^0. For a sweep wing, it is observed that there is no change in the pressure on bottom surface and top surface of the wing, so the pressure distribution is almost equal on the entire wing.

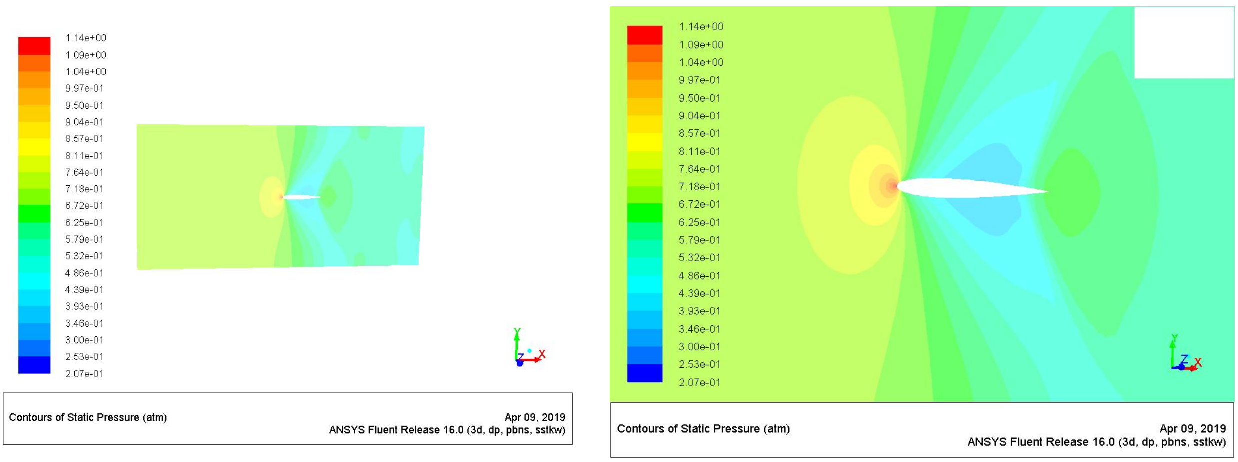


Figure 3: Wing without Morphing and for 0^0 AOA.

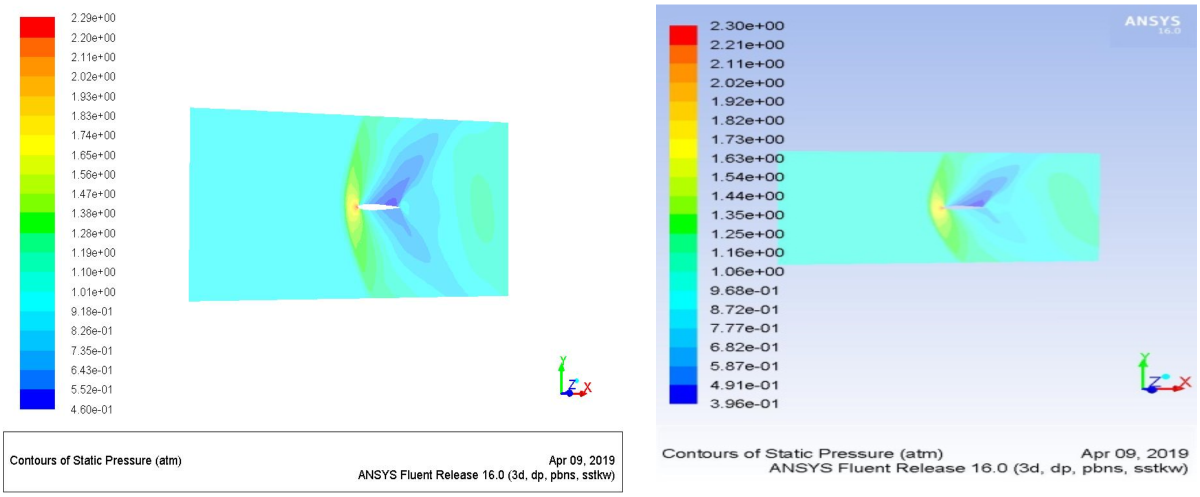
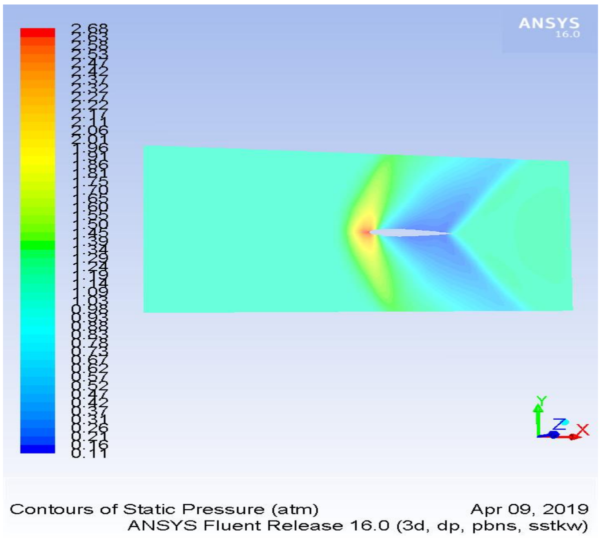
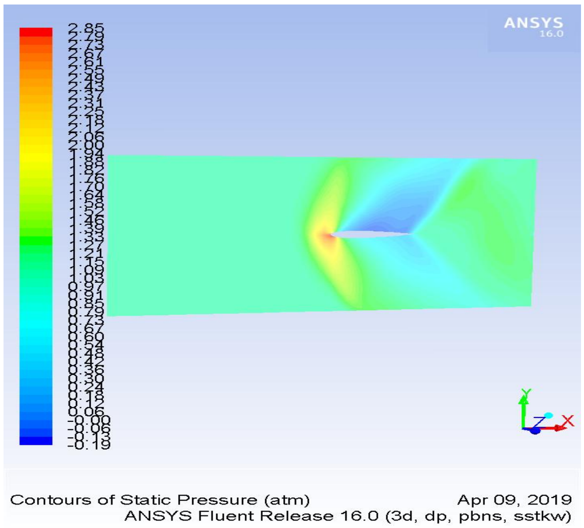


Figure 4: Wing without Morphing and for 3^0 and 6^0 AOA.

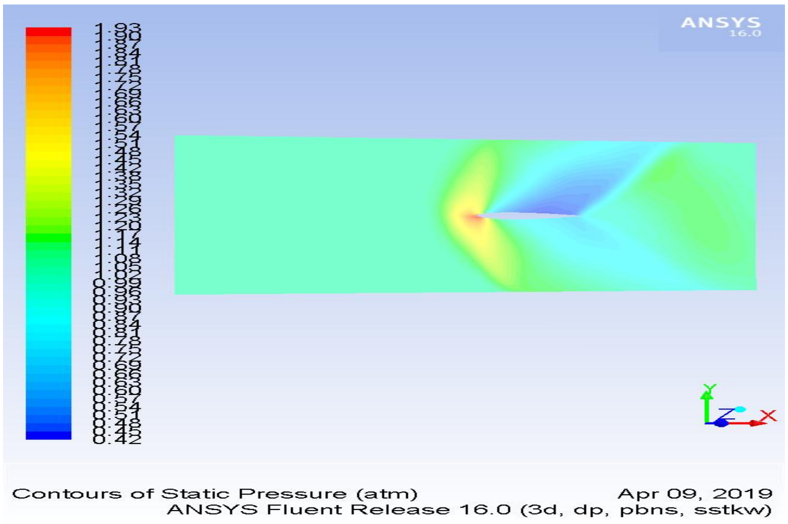
When a wing increases its AOA to 3°, a variation of pressure is recorded. Top surface occupies less pressure, whereas bottom surface occupies higher pressure. Even when the AOA is further increased to 6°, the pressure generated on top surface of the wing is too weak, whereas on the bottom surface, it is too strong. Finally, the lift increases from 0:0012 KN to 0:0256 KN for AOA of 3° and it further increases to 0:059 KN by increase in AOA of 6°. When a wingspan is morphed for 20%, entire result increases, as the span area increased. Similarly, we performed our study on all 3AOA (0^0, 4^0, 6^0). So, the pressure distribution is almost equal on the entire wing, but when a wing increases its AOA to 3°, a variation of pressure is recorded. Top surface occupies less pressure, whereas bottom surface occupies higher pressure. Even when the AOA is further increased to 6°, the pressure generated on top surface of the wing is too weak, whereas on the bottom surface, it is too strong. Finally, the lift increases from 5:79 KN to 7:87 KN for AOA of 3° and it further increases to 13.89 KN.



0^0 AOA.



3^0 AOA.



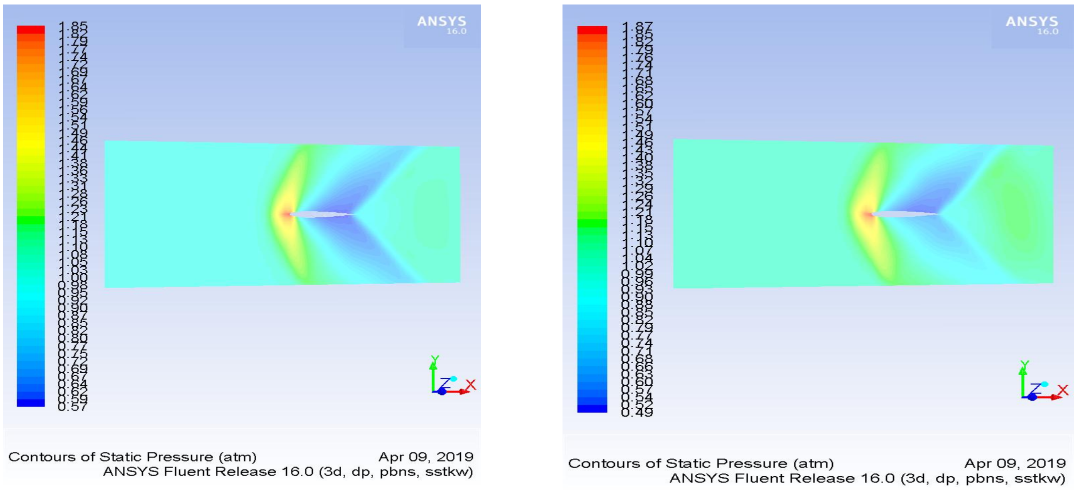
6^0 AOA.

Figure 5: Pressure Contour of Wing Morphing for 20%.

For Wing Morphing 40%

Further, the wing span is morphed for 40%, which increases aerodynamic loads drastically, as the span area increased to 1.4 times the previous. So, the pressure distribution is almost equal on the entire wing, but when a wing increases its AOA to 3°, a variation of pressure is recorded. Top surface occupies less pressure, whereas bottom surface occupies higher pressure.

Even when the AOA is further increased to 6°, the pressure generated on the top surface of the wing is too weak, whereas on the bottom surface, it is too strong. Finally, the lift increases from 11:6 KN to 15:7 KN for AOA of 3° and it further increases to 27:8 KN by an increase in AOA of 6°.



0^0 AOA. **3^0AOA.**

Figure 6: Pressure Contour of Wing Morphing for 40%.

CONCLUSIONS

Finally, the paper concludes with an increase in the lift by increasing the wingspan area. It is recorded that a sweep wing without morphing is also generating lift slightly and the lift generation is increased from 0:0012 KN to 0.0256 KN by

morphing span to 20% and 0.0012 KN to 0.0509 KN by morphing span to 40%.

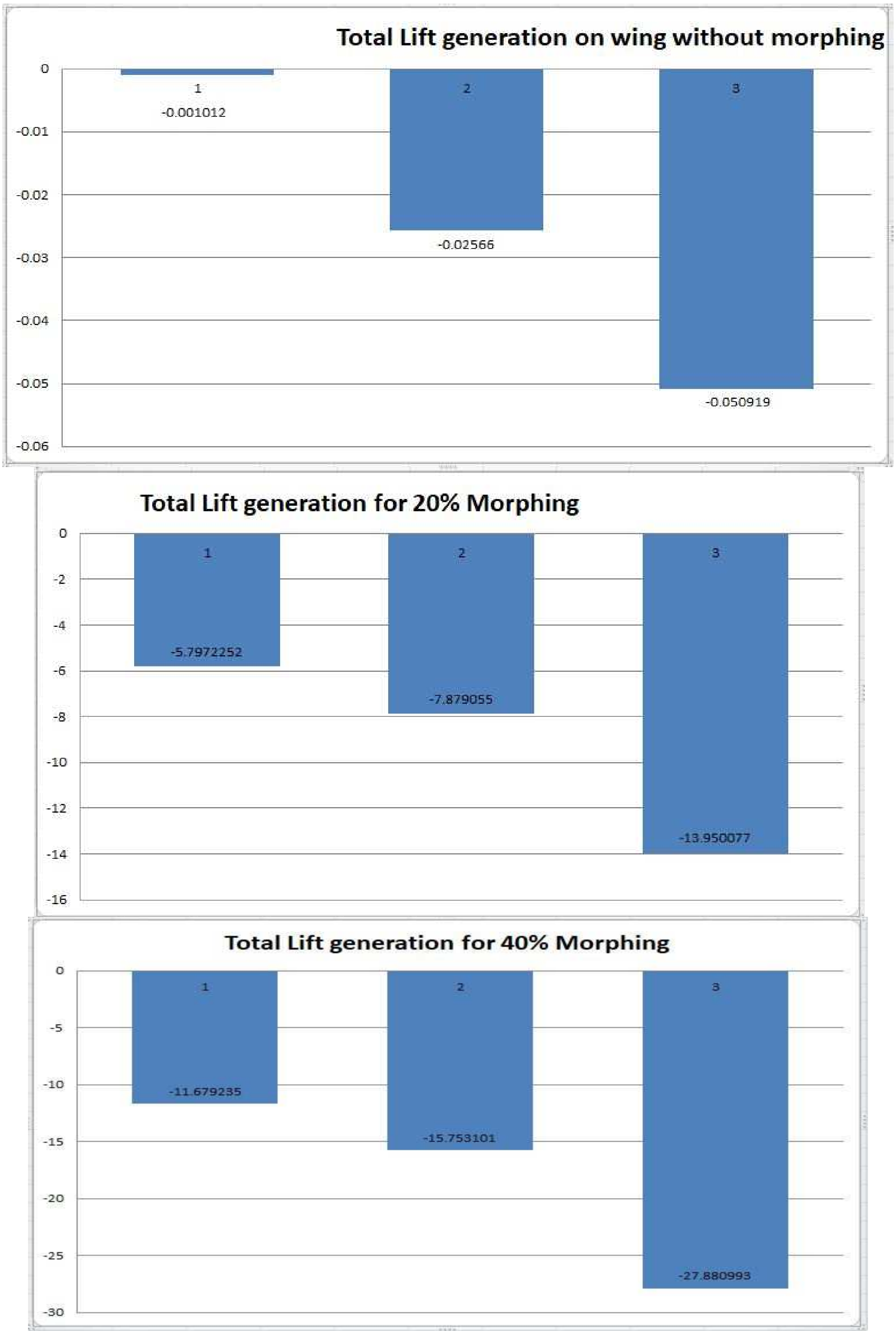


Figure 7: Graph of Lift Plot for Wing without Morphing and with Morphing of 20% and 40%.

Further, when an Angle of Attack is increased to 3^0, there is a change in lift, which is resulted as 5.79 KN for a sweep wing, later on by morphing of span for 20°, a lift generated as 7:87 KN, and when the wing is morphed span wise for 40%, a 13.89 KN lift is generated. Even more when an Angle of Attack is increased to 6^0, an observation is conducted to locate the change in lift, which resulted as 11.6 KN, for a sweep wing, later on by morphing of span for 20°, a lift generated as 15.7 KN and when the wing is morphed span wise for 40%, a 27.8 KN lift is generated.

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